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AUTHOR Berger, Carl F.; Roderick, Stephen A.
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ABSTRACT

Groups of teachers in and around Ann Arbor, Michigan identified 143 characteristics a competent elementary school teacher should have in order to teach science. When teacher educators were asked to rate these competencies major discrepancies became obvious. Teacher educators placed a very important value on competencies which were rated low or as having no value by practicing teachers. Such differences in perception become critical when practicing teachers evaluate the performance of student teachers whose goals are more likely to be those advocated by teacher educators. Further, teachers and teacher educators differed significantly in their estimations of when a competency should be attained. Three conclusions can be drawn from this preliminary research: (1) Teacher educators appear to attach less importance to classroom discipline and record keeping and more importance to working with students; (2) Teacher educators appear to believe that competencies should be attained earlier in the student's career; and (3) The differences found between teachers and teacher educators indicate that assessment of the competencies themselves is as important a task as assessing student's attainment of the tasks and should be included in any competency based program. The 143 competencies are included in the Appendix. (EH)

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CBTE: A Critical Look

Evaluating and Assessing Competencies for Elementary Science Education

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Carl F. Berger
Stephen A. Roderick

The University of Michigan

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Evaluating and Assessing Competencies for Elementary Science Education

Carl Berger - Steve Roderick
The University of Michigan
Ann Arbor, Michigan

The evaluation and assessment of competencies has two large components. The first is the evaluation of the competency itself, the second is the evaluation of students to find how well they have obtained the stated competency. This paper addresses the former.

Under a grant from the Michigan State Department of Education, the University of Michigan in cooperation with the elementary school teachers in the Ann Arbor, Michigan area developed a list of 230 competencies. The competencies were chosen as "Characteristics a competent elementary teacher should have in order to teach science."[1] Four teams of four to five teachers each were formed to develop the competencies. To first evaluate the competencies, similar competencies from each group were edited to obtain a single competency statement. Then the competencies were ranked by the teachers as to importance for elementary science teaching and how much involvement the University of Michigan should have in developing the competency. Teachers rated the competencies from 1 to 7 in importance and 1 to 4 in University involvement. The ratings of 14 teachers and 4 teacher educators were analyzed. Means and standard deviations were generated

for all competencies. Competencies were removed if two conditions were met. The competency had to be rated less than average in importance and also be rated in the lower quartile for University involvement. Of the 230 competencies, 50 met both conditions and were considered for dropping. Analysis of those competencies considered for rejection indicated a difference in ratings between teachers and teacher educators. To find if the difference in rating was significant, data about the 230 competencies were run through the MIDAS computer program system where a Mann Whitney U Test was performed.[2] The Mann Whitney U Test was performed because it allows relaxation of parametric assumptions of normality necessary for a small N.[3] Of the 230 competencies, 44 (approximately 20%) were significantly different at the $\alpha = .05$ level in either importance for science teaching or University of Michigan involvement. A list of the 44 competencies showing such differences is shown in Appendix I. Competencies which occurred on this list and were included in the list of 50 competencies which were selected for removal were reinstated for purposes of future research.

Independent consensus and editing was done during this time by assessment specialists. The project staff synthesized the products and further reduced the list to a final list of 143 competencies. This list may be found in Appendix II. The impact of differences between teachers in the field and teacher educators to a teacher education program cannot be overstated. As an example, supervising teachers in the field may place a very important value on competencies which have received low or no value by teacher educators. Such differences in perception may create critical problems for student teachers who may not be aware of the source of such problems.

To further explore differences between teachers and teacher educators as they ranked competencies, the sample was increased. The resulting data base consisted of 22 teachers and 18 teacher educators. Analysis of variance indicated that more differences occurred when teachers in areas around Ann Arbor were included (8) and teacher educators not directly involved in science education were included (11). Differences in ratings occurred in 66 of 143 competencies (approximately 46%).

Of interest was the distribution of differences comparing when a competency should be attained. Using modes of the entire sample the competencies were categorized as to when the competency should be obtained. The categories and differences in ratings between teachers and teacher educators are shown in Table 1.

Table 1

Categories and Differences between Teachers and Teacher Educators on Ratings of Competencies

Category	Differences in Percent
1) Before entering an education program.	40%
2) Initial field experience (observation).	30%
3) Undergraduate education courses.	45%
4) Student teaching.	41%
5) In-service experience.	73%
6) In-service workshops, professional meeting and education courses.	100%

The 66 competencies which indicated a difference in ratings between teachers and teacher educators are shown in Appendix III. Numbers appearing beside each competency indicate the category. The direction of difference is indicated by an asterisk beside each of those competencies rated as more important or should be attained earlier by teacher educators. Note that 25 of 33 competencies (75%) were rated as should be attained earlier by teacher educators. Note also that 22 of 31 competencies (71%) were rated as more important by teacher educators

As can be concluded from this preliminary research, teacher educators appear to attach less importance to classroom discipline and record keeping and more importance to working with students. Teacher educators appear to believe that competencies should be attained earlier in the student's career.

Finally, the differences found between teachers and teacher educators indicate that assessment of the competencies themselves is as important a task as assessing student's attainment of the tasks and should be included in any competency based program.

References Cited

(1) Berger, C., Roderick, S. and Latz, M. 1975. The Development of a Competency Based Teacher Preparation Model for Elementary Science Education. University of Michigan, Ann Arbor.

(2) Fox, D. and Guire, K. 1973. Michigan Interactive Data Analysis System. University of Michigan, Ann Arbor.

(3) Siegal, S. 1956. Nonparametric Statistics for the Behavioral Sciences. McGraw Hill, New York.

APPENDIX I

COMPETENCIES WITH SIGNIFICANT DIFFERENCES

BETWEEN TEACHERS

AND

TEACHER EDUCATORS

18500 UTILIZE FREE AND INEXPENSIVE MATERIALS
18764 UTILIZE PROCESS OF MEASURING (METRIC)
20404 ESTABLISH WITH CHILDREN IMPORTANCE OF APPLYING SCIENCE KNOWLEDGE IN CE
21203 SELECT AND INVOLVE COMMUNITY RESOURCES
22603 PARTICIPATE IN INSERVICE WORKSHOPS
22904 RELATE SCIENCE TO DAILY LIFE
23102 MAINTAIN ROOM CLEANLINESS AND ORGANIZATION WITH CHILDREN
23702 LOCATE AND EVALUATE NEW MATERIALS
24004 EVALUATE ACTIVITY AND REORGANIZE WHEN UNSUCCESSFUL
24404 INCORPORATE ORGANIZATION IN PREPARATION AND ARRANGEMENT OF MATERIALS
25402 SYNTHESIZE RELEVANT MATERIAL INTO THE CURRICULUM
25502 PLAN CHILD-CENTERED ACTIVITIES
25802 MAINTAIN EFFECTIVE CLASSROOM CONTROLS
26023 INCORPORATE FEEDBACK FROM STUDENTS
26604 RESPOND TO UNEXPECTED SITUATIONS EFFICIENTLY AND WITH COMMON SENSE
26803 PREPARE LESSON PLANS AND MATERIALS
28202 EVALUATE PROGRESS ON GOALS WITH INDIVIDUAL CHILDREN AND GROUPS OF CHIL
28304 DESIGN SCIENCE MATERIALS FROM TRASH OR JUNK
30944 DEMONSTRATE PROPER CLASSROOM CARE FOR LIVING THINGS
31202 RECOGNIZE POSITIVE STUDENT INFORMATION AND SHARE IT WITH OTHER TEACHER
31304 UTILIZE MEASURING SYSTEMS WHICH ARE RELEVANT TO STUDENTS
31502 USE LIBRARY RESOURCES OF SCHOOL OR COMMUNITY
31801 PROVIDE ATMOSPHERE FOR RESPECT
32002 UTILIZE IN-SERVICE TRAINING OPPORTUNITIES
32203 ASK DIFFERING COGNITIVE QUESTIONS
32703 ESTABLISH MEDIA CENTER FOR INDIVIDUAL RESEARCH
32902 DEMONSTRATE ABILITY TO EFFECTIVELY COMMUNICATE WITH VARIOUS TYPES OF S
33704 DEVELOP IN STUDENTS EXCITEMENT AND ENTHUSIASM FOR SCIENCE
34103 USE A VARIETY OF CLASSROOM OBJECTIVES
34502 VISIT OTHER CLASSROOMS
34704 REGAIN POSITIVE EQUILIBRIUM AFTER DISCOURAGING EVENTS
35504 DEVELOP LESSONS WHICH RELATE TO THE STUDENTS
36804 CONTROL EXPERIMENTAL VARIABLES

36902	USE VARIETY OF AUDIO-VISUAL MATERIALS
37102	DESIGN REALISTIC TESTS AND WORKSHEETS
37201	SELECT COLLECTION MATERIALS CRITICALLY
37804	IDENTIFY VALUE FOR MAINTAINING LIVING THINGS IN THE CLASSROOM
39434	UTILIZE PROCESS OF HYPOTHESIS TESTING
39601	KEEP RECORDS OF MATERIALS
39802	PERFORM DEMONSTRATIONS
40423	FORMULATE ACCURATE UP-TO-DATE RECORDS OF STUDENT ACHIEVEMENT
40803	DEVELOP VOCABULARY OPERATIONALLY (THROUGH USE)
41300	CONSTRUCT SIMPLE EQUIPMENT
41400	UTILIZE PROFESSIONAL JOURNALS FOR INSTRUCTION AND RESEARCH

APPENDIX II

MASTER LIST OF ELEMENTARY SCHOOL

SCIENCE TEACHING COMPETENCIES

BY CATEGORY

MASTER LIST OF ELEMENTARY SCHOOL SCIENCE TEACHING COMPETENCIES

BY CATEGORY

ACADEMIC BACKGROUND

	193	DEMONSTRATE UNDERSTANDING OF CONSTANT CHANGE
	197	DEMONSTRATE UNDERSTANDING OF ECOSYSTEMS
	220	KNOW DEVELOPMENTAL STAGES
	223	DEMONSTRATE ABILITY TO RESEARCH AND ORGANIZE FACTS
	239	KNOW CONTENT ENOUGH TO RESPOND TO STUDENT QUESTIONS
	252	KNOW METHODS OF SCIENTIFIC INQUIRY
	257	KNOW MICHIGAN MINIMAL PERFORMANCE OBJECTIVES
	277	DEMONSTRATE UNDERSTANDING OF SPACE AND TIME CONCEPTS
	298	DEMONSTRATE UNDERSTANDING OF STRUCTURAL PATTERN CONCEPTS
*	309	DEMONSTRATE PROPER CLASSROOM CARE FOR LIVING THINGS
	353	DEMONSTRATE UNDERSTANDING OF GEOLOGICAL CONCEPTS
	375	UTILIZE LOGIC IN SCIENTIFIC INVESTIGATION
	382	DEMONSTRATE UNDERSTANDING OF CONSERVATION OF MATTER AND ENERGY
	387	DEMONSTRATE UNDERSTANDING OF INTERDEPENDENCE OF LIVING OBJECTS
	399	DISCRIMINATE PROPERTIES OF LIVING AND NONLIVING OBJECTS AND CLASSIFY
	405	DEMONSTRATE UNDERSTANDING OF ENERGY CONCEPTS
	406	DEMONSTRATE UNDERSTANDING OF INTERACTION CONCEPTS

ASSESSMENT

	189	EVALUATE APPROPRIATENESS OF MATERIALS AND ACTIVITIES RELATIVE TO THE &
	210	EVALUATE SCIENCE PROGRAMS
	230	EVALUATE LESSONS AND TEACHING PROCEDURES
*	240	EVALUATE ACTIVITY AND REORGANIZE WHEN UNSUCCESSFUL
	250	ANALYZE SITUATION TO DETERMINE APPROPRIATE ASSESSMENT MODES
*	260	INCORPORATE FEEDBACK FROM STUDENTS AND PARENTS
	273	GENERATE CONSTANT FEEDBACK TO STUDENTS
	281	APPLY CONTINUOUS SELF-EVALUATION PROCEDURES
*	282	EVALUATE PROGRESS ON GOALS WITH INDIVIDUALS AND GROUPS
	287	FORMULATE REALISTIC GROUP AND INDIVIDUAL EXPECTATIONS
	292	EVALUATE USE OF MEDIA
	356	EVALUATE INTERACTION OF SELF AND STUDENTS
	367	INVOLVE CHILDREN IN SELF-EVALUATION
	395	EVALUATE HOW WELL EACH CHILD'S NEEDS HAVE BEEN MET
*	396	KEEP RECORDS OF MATERIALS
*	404	FORMULATE ACCURATE UP-TO-DATE RECORDS OF STUDENT ACHIEVEMENT

* Those competencies with significant differences in ratings among teachers and teacher educators.

CLASSROOM MANAGEMENT

	191	DEMONSTRATE ABILITY TO MANAGE GROUPS OF VARIOUS SIZES
	216	ORGANIZE CLASSROOM WITH CHILDREN TO PROVIDE LEARNING VARIETY
	222	ESTABLISH A CREATIVE AND ATTRACTIVE LEARNING ENVIRONMENT
*	231	MAINTAIN ROOM CLEANLINESS AND ORGANIZATION WITH CHILDREN
	233	FORMULATE ROUTINES AND CLASSROOM LIMITS WITH CHILDREN
*	258	MAINTAIN EFFECTIVE CLASSROOM DISCIPLINE
*	266	RESPOND TO UNEXPECTED SITUATIONS EFFICIENTLY AND WITH COMMON SENSE
	288	ESTABLISH ENVIRONMENT TO ENCOURAGE ORGANIZATION AND SHARING
	366	ESTABLISH AN OPEN, RELAXED CLASSROOM ENVIRONMENT
	370	DEMONSTRATE SENSE OF FAIRNESS THROUGH CONSISTENCY
	402	ESTABLISH CLASSROOM ENVIRONMENT WHICH DEVELOPS INDIVIDUAL LEARNING

CURRICULUM

*	187	INVOLVE STUDENTS IN UTILIZING THE PROCESS OF MEASURING (METRIC)
	192	INVOLVE STUDENTS IN UTILIZING THE PROCESS OF COMMUNICATING
*	229	ADAPT MATERIAL RELATING TO DAILY LIFE INTO THE CURRICULUM
	246	UTILIZE VARIOUS SUB-GROUPS OF SOCIETY AND OF THE LOCAL COMMUNITY&
*	254	SYNTHESIZE RELEVANT MATERIAL INTO THE CURRICULUM
	259	INVOLVE STUDENTS IN UTILIZING THE PROCESS OF OBSERVING
	284	INVOLVE STUDENTS IN UTILIZING THE PROCESS OF INTERPRETING DATA
	285	INVOLVE STUDENTS IN UTILIZING THE PROCESS OF CLASSIFYING
	286	SELECT CONTENT WITH SUFFICIENT DEPTH FOR MULTIPLE ACTIVITIES
	289	INVOLVE STUDENTS IN UTILIZING THE PROCESS OF PREDICTING
	294	DEVELOP CONCEPT OF INTERRELATIONSHIP OF ORGANISMS AND THEIR ENVIRONMEN
*	313	UTILIZE MEASURING SYSTEMS WHICH ARE RELEVANT TO STUDENTS
	334	DEVELOP AND USE CLEARLY DEFINED PERFORMANCE OBJECTIVES
	363	INVOLVE STUDENTS IN UTILIZING THE PROCESS OF RECORDING
*	378	PROVIDE GUIDANCE IN STUDENT MAINTAINANCE OF ORGANISMS IN CLASSROOM
	381	INCORPORATE READING AND MATH SKILLS
	392	ESTABLISH CONTENT BACKGROUND APPROPRIATE TO TEACHING LEVEL
	393	INVOLVE STUDENTS IN UTILIZING THE PROCESS OF FORMULATING HYPOTHESIS
*	394	INVOLVE STUDENTS IN UTILIZING THE PROCESS OF HYPOTHESIS TESTING

MATERIALS

*185	UTILIZE FREE AND INEXPENSIVE MATERIALS
*237	LOCATE AND EVALUATE NEW MATERIALS
243	SELECT AND USE APPROPRIATE MEDIA, MATERIALS, AND RESOURCES
*244	INCORPORATE ORGANIZATION IN PREPARATION AND ARRANGEMENT OF MATERIALS
263	PREPARE LIVING MATERIALS FOR CLASSROOM USE
276	OPERATE SCIENCE EQUIPMENT
*283	DESIGN SCIENCE MATERIALS FROM TRASH OR JUNK
303	USE RELEVANT PRINTED MATERIALS
323	MODIFY MATERIALS FOR CLASSROOM ACTIVITIES
*327	ESTABLISH MEDIA CENTER FOR INDIVIDUAL RESEARCH
332	CONSTRUCT AND CARE FOR AQUARIA AND TERRARIA
346	LOCATE SCIENCE EQUIPMENT SOURCES FOR A SPECIFIC CLASSROOM/TEACHER
357	FIND APPROPRIATE REFERENCE MATERIAL
*369	USE AND OPERATE A VARIETY OF AUDIO-VISUAL MATERIALS AND/OR EQUIPMENT
*372	SELECT COLLECTION MATERIALS CRITICALLY (E.G., ROCKS AND MINERALS)
385	PLAN AND ORGANIZE FOR USE OF MANIPULATIVE MATERIALS
390	USE A VARIETY OF MATERIALS
*413	CONSTRUCT SIMPLE EQUIPMENT

PERSONAL DEVELOPMENT (PUPIL OR TEACHER)

209	GUIDE CHILDREN IN MAKING REALISTIC GOALS AND CHOICES
214	EXPAND PROFICIENCY IN SCIENCE EDUCATION BEYOND PRESERVICE
*226	PARTICIPATE IN INSERVICE WORKSHOPS
290	ORGANIZE EXPERIENCES WHICH WILL GIVE CHILDREN POSITIVE RELATIONSHIPS &
308	RECOGNIZE ASSET OF HUMOR AND UNPLANNED DISCOVERY IN CLASSROOM EXPERIE&
*318	PROVIDE ATMOSPHERE FOR RESPECT
*320	UTILIZE IN-SERVICE TRAINING OPPORTUNITIES
326	DEVELOP CONTINUING INTEREST IN NEW SCIENCE FINDINGS
*329	DEMONSTRATE ABILITY TO EFFECTIVELY COMMUNICATE WITH VARIOUS PEOPLE
344	APPRECIATE VALUE IN STUDENT RESPONSE
*345	VISIT OTHER CLASSROOMS
*347	REGAIN POSITIVE EQUILIBRIUM AFTER DISCOURAGING EVENTS
354	DEMONSTRATE FOLLOW THROUGH ON COMMITMENTS
359	BE TACTFUL WITH STUDENTS
384	SHARE MUTUAL RESPECT FOR SELF AND OTHERS
397	RECOGNIZE INDIVIDUAL CHILD'S GOALS, STRENGTHS, WEAKNESSES, NEEDS

PHILOSOPHY

321	CREATE AN APPRECIATION FOR THE BEAUTY, WONDER AND OPENNESS OF SCIENCE
271	DISTINGUISH BETWEEN VALUE JUDGMENT AND POINT OF VIEW

RESOURCES

*	212	SELECT AND INVOLVE COMMUNITY RESOURCES
	232	USE STUDENTS AS RESOURCE
*	315	USE LIBRARY RESOURCES OF SCHOOL OR COMMUNITY
	342	USE ENVIRONMENT AS A SCIENCE LABORATORY
*	414	USE PROFESSIONAL JOURNALS FOR INSTRUCTION AND RESEARCH

SAFETY

	202	RECOGNIZE AND EVALUATE SAFETY HAZARDS IN EVERYDAY EXPERIENCES
	251	USE SAFETY PROCEDURES IN SCIENCE EXPERIMENTS AND DEMONSTRATIONS
	306	KNOW STATE AND SCHOOL SAFETY RULES
	325	STRUCTURE ACCIDENT PROCEDURES FOR CHILDREN
	333	DEVELOP SAFETY CONSCIOUSNESS IN THE STUDENTS

TEACHING STRATEGIES

	186	UTILIZE GAMES AND SIMULATIONS
	201	PLAN AND CONDUCT FIELD TRIPS
*	204	ESTABLISH WITH CHILDREN IMPORTANCE OF APPLYING SCIENCE KNOWLEDGE
	217	USE POSITIVE REINFORCEMENT TECHNIQUES
	228	USE VARIOUS QUESTIONING TECHNIQUES , COGNITIVE AND AFFECTIVE
	235	INCORPORATE SPONTANEOUS CLASSROOM CHANGES INTO LESSONS
*	255	PLAN CHILD-CENTERED ACTIVITIES
	261	PROVIDE FOR ACTIVE STUDENT PARTICIPATION AND DISCUSSION
	264	PLAN ACTIVITIES APPROPRIATE TO AVAILABLE TIME
*	268	PREPARE LESSON PLANS AND MATERIALS
	275	USE INDUCTIVE AND DEDUCTIVE REASONING
	279	USE STUDENT'S IDEA TO DEVELOP LOGICAL SOLUTION TO A PROBLEM
	299	UTILIZE TEACHING BEHAVIORS WHICH MOTIVATE STUDENTS
	300	DEVELOP QUESTIONING OF CONCLUSIONS
	310	ASK QUESTIONS APPROPRIATE TO CONTENT AND AGE LEVEL
	311	FORMULATE MEANINGFUL EXPERIENCE FROM EXPERIMENTAL FAILURE
	314	INCORPORATE AN ATMOSPHERE OF SCIENTIFIC CURIOSITY AND CONDUCT
	319	REFRAIN FROM FORCING CONCLUSIONS
*	322	ASK DIFFERING COGNITIVE QUESTIONS
	331	ESTABLISH OPEN-ENDED DISCUSSIONS
	336	USE PUPIL-TEACHER AND PUPIL-PUPIL PLANNING
*	337	DEVELOP IN STUDENTS EXCITEMENT AND ENTHUSIASM FOR SCIENCE
	338	USE EXPERIMENTS WHICH UTILIZE THE SCIENTIFIC PROCESSES
	343	PROVIDE INDIVIDUAL AND GROUP INSTRUCTION
*	355	DEVELOP LESSONS WHICH RELATE TO THE STUDENTS
	361	DEVELOP SELF-DIRECTIVE SMALL GROUPS
*	368	CONTROL EXPERIMENTAL VARIABLES
	373	PROVIDE A VARIETY OF LEARNING SITUATIONS
	383	PROVIDE FOR FURTHER STUDENT INQUIRY
	386	USE PROBLEM APPROACH
*	398	PERFORM DEMONSTRATIONS
	401	IMPLEMENT A VARIETY OF ACTIVITIES CONCURRENTLY
	403	INVOLVE STUDENTS IN OPEN EXPLORATION
*	408	DEVELOP VOCABULARY OPERATIONALLY (THROUGH USE)

APPENDIX III

COMPETENCIES IN WHICH THERE WERE SIGNIFICANT DIFFERENCES BETWEEN RATINGS OF TEACHERS AND TEACHER EDUCATORS

When the Competency should be First Attained

Before entering an education program

Develop concept of interrelationship of organisms and their environment. (1*)
Demonstrate ability to effectively communicate with various people. (1*)
Regain positive equilibrium after discouraging events. (1*)
Respond to unexpected situations efficiently and with common sense. (1-)

Initial field experience (observation)

Use library resources of school or community. (2*)

Undergraduate education courses

Use professional journals for instruction and research. (3-)

Student teaching

Use student's idea to develop logical solution to a problem. (4*)
Develop questioning of conclusions. (4-)
Guide children in making realistic goals and choices. (4*)
Involve students in utilizing the process of hypothesis testing.(4*)
Develop safety consciousness in the students. (4*)
Develop in students excitement and enthusiasm for science. (4-)
Develop lessons which relate to the students. (4*)
Involve students in utilizing the process of measuring (metric). (4*)
Control experimental variables. (4*)
Select and involve community resources. (4*)
Formulate accurate up-to-date records of student achievement. (4*)
Provide atmosphere for respect. (4-)
Establish open-ended discussions. (4*)
Use various questioning techniques, cognitive and affective. (4*)
Formulate meaningful experience from experimental failure. (4-)
Incorporate spontaneous classroom changes into lessons.(4*)
Demonstrate proper classrom care for living things. (4*)
Provide guidance in student maintainance of organisms in classroom. (4*)

In-service experience.

Establish with children importance of applying science knowledge. (5*)
Structure accident procdures for children. (5*)
Locate science equipment sources for a specific classroom/teacher. (5*
Utilize various sub-groups of society and of the local community when planning instruction. (5*)
Adapt materials relating to daily life into the curriculum. (5-)
Analyze situation to determine appropriate assessment modes. (5*)

In-service experience con't.

Apply continuous self-evaluation procedures. (5*)
Establish media center for individual research. (5-)

In-service workshops, professional meetings and education courses

Develop continuing interest in new science findings. (6*)

Competencies in which there were Significant Differences between Ratings of Teachers and Teacher Educators

Importance for Science Teaching

Before entering an education program

Recognize and evaluate safety hazards in everyday experiences. (1*)
Demonstrate follow through on commitments. (1*)
Share mutual respect for self and others. (1*)
Distinguish between value judgment and point of view. (1*)
Know methods of scientific inquiry. (1*)

Initial field experience (observation)

Utilize free and inexpensive materials. (2*)
Visit other classrooms. (2*)

Undergraduate education courses.

Plan child-centered activities. (3*)
Select collection materials critically (e.g., rocks and minerals). (3-)
Design science materials from trash or junk. (3*)
Incorporate organization in preparation and arrangement of materials. (3-)
Construct simple equipment. (3*)
Use problem approach. (3*)
Use and operate a variety of audio-visual materials and/or equipment. (3-)
Prepare lesson plans and materials. (3*)
Locate and evaluate new materials. (3*)

Student teaching

Maintain effective classroom discipline. (4-)
Perform demonstrations. (4-)
Maintain room cleanliness and organization with children. (4-)
Evaluate progress on goals with individuals and groups. (4*)
Utilize measuring systems which are relevant to students. (4*)
Construct and care for aquaria and terraria. (4*)
Evaluate activity and reorganize when unsuccessful. (4-)
Develop vocabulary operationally (through use). (4-)
Ask differing cognitive questions. (4*)

In-service experience

Keep records of materials. (5-)
Incorporate feedback from students and parents. (5*)
Synthesize relevant material into the curriculum. (5*)

In-service workshops, professional meetings and education courses

Participate in in-service workshops. (6*)
Utilize in-service training opportunities. (6*)
Expand proficiency in science education beyond pre-service. (6*)